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SILKWORM CULTURE.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., March 5, 1903.

Sir: I transmit herewith an article on silkworm culture, prepared by Miss Henrietta Aiken Kelly, special agent in silk investigations of this Division, and recently published as Bulletin No. 39 (new series) of this Division, to which has been added a few paragraphs of information on the culture of the mulberry, condensed from Bulletin No. 34 of the Bureau of Plant Industry.

Miss Kelly has studied the culture of the mulberry silkworm as carried on in France and Italy for a number of years, has consulted the works of the best European authorities, and is therefore well qualified for this task. Although the silkworm industry has not attained much commercial importance in the United States, there is a popular demand for information on the subject which, it is believed, can be supplied to the best advantage by the republication of this matter in the popular Farmers' Bulletin series.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

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SILKWORM CULTURE.

The caterpillars of many moths and of a few butterflies produce silk, but certain of those belonging to the family Bombycidae, or true silk-spinners, particularly *Bombyx (Sericaria) mori*, or the mulberry silkworm, yield the most and the best silk. The races of *Bombyx mori* to-day are the result of domestication and artificial rearing, and the wild type is uncertain, though most authorities assign the foot of the Himalaya as the cradle of the mulberry silkworm. It has been industrially cultivated in China from time immemorial, and in Europe since the sixth century.

THE LIFE OF THE SILKWORM.

Like all insects of its class, before arriving at the perfect winged state, it exists (1) as a caterpillar or larva, and (2) in a chrysalis state.

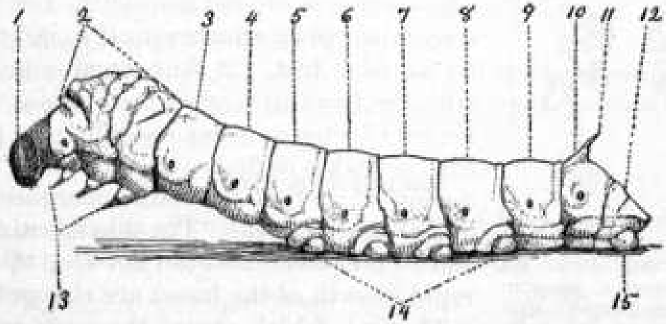

FIG. 1.—Adult silkworm: 1, head; 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, rings; 11, horn; 13, 3 pairs of articulated legs; 14, 4 pairs of abdominal or false legs; 15, a pair of false legs on the last ring.

THE LARVA, OR CATERPILLAR.

The larva (fig. 1) has a cylindrical body composed of 12 rings; each of the first three has a pair of jointed legs, and the sixth, seventh, eighth, ninth, and twelfth each bears a pair of false legs, destined later to disappear.

The black elliptical spots on the side are the orifices for breathing, and are called stigmata or spiracles.

The head is a small mass covered with a hard scale, and is provided with jaws that move laterally, like the wings of a folding door. The alimentary canal extends throughout the entire length of the body,

and on each side of it is placed a silk gland (fig. 2). These consist of two whitish or amber-colored cords, which after innumerable curves unite in the spinneret in the region of the mouth. There are also two glands, whose excretory canal opens in the spinneret, and covers the silk as it comes out with an impermeable varnish rendering it insoluble in acids and alkalies. This varnish is about a fifth of the weight of the thread.

Hatchings usually occur annually in the spring. Simple contact with the air causes the new-born insect immediately to acquire a volume larger than it had in the egg, and it quickly begins to gnaw the under surface and edges of the mulberry leaf. It eats day and night at all hours, except when asleep, and in about thirty days grows 14,000 times larger than it was at birth.

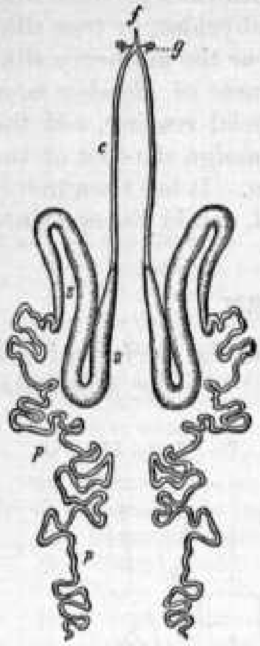

FIG. 2.—Silk glands in a mature worm: *p*, portion of glands which secrete the silky matter; *s*, reservoir; *c*, conducting canal; *f*, spinneret; *g*, accessory glands (redrawn from Verson and Quajat).

As the silkworm grows larger it becomes paler in color, because its dark chestnut brown hairs are scattered over a larger surface, thus showing more of the true color of the skin.

About five days from its birth the vitality of the larva decreases, and it eats scantily or not at all, and becomes thin and whitish in color. Then it moves around unquietly, and finding a convenient place attaches itself to it, holding on by its false feet. It thus remains motionless, with the front part of its body raised up, for a period of time varying according to temperature, and takes its first so-called "sleep," or molt, during which time the body undergoes extraordinary modifications. The skin is entirely shed, and all the tissues that can not keep up with the rapid growth of the insect are changed.

The scale which covers the snout is the first part of the case to fall, and a new case appears under the former one. The worm then pushes itself forward through its first ring, sets at liberty the legs of the thorax, and by a wriggling movement comes out of its old sheath.

To facilitate this difficult change a liquid is secreted between the old skin and the one forming beneath it.

The life of the larva is usually divided into four ages, varying in length according to temperature, frequency of feeding, race, and the robustness of the worm. The following is about the average:

First age, from birth to first molt, five to six days.
Second age, from first to second molt, four days.
Third age, from second to third molt, four to five days.
Fourth age, from third to fourth molt, five to seven days.
Fifth age, from fourth molt to maturity, seven to twelve days.

Some time after each molt, perhaps the time needed to regain lost strength and to solidify the newly-formed organs, the worm remains in a state of relative torpor. Not much practice is needed to recognize when it has come out of its "sleep." It moves its head and thorax, which are whitish, while the rest of the body is gray, and has completely lost the shining aspect which it had when the worm began to molt. When fairly through its first molt the larva begins again to eat, and its hunger does not cease until it is ready for a new molt.

Four molts having been made, the worm eats a prodigious quantity of leaf until it reaches its maximum growth, when its appetite diminishes and ceases altogether. It then stops moving and remains for some time in repose, evacuating, meanwhile, its digestive canal, thus losing up to 12 per cent of its weight. Its lean body is now white or yellow, according to the race, and semitransparent.

Very soon it begins to move about again, lifts up its head, which is longer and more pointed, and turns in every direction seeking to find a convenient angle, finding which, it throws out a silk thread from its spinneret. First a net is formed to hold the cocoon which is to be spun, then the regular spinning begins and the form of the cocoon is designed. For some time through the veil which very soon is to surround it, the diligent larva, with its back turned outward, may be seen completing its task. It is calculated that with its head alone the silkworm makes 69 movements every minute, describing arcs of circles, crossed in the form of the figure 8 (fig. 3, *a*).

Meanwhile the web grows closer and the veil thickens, and in about seventy-two hours the worm is completely shut up in its cocoon, which serves it as a protective covering.

THE CHRYSALIS.

In the cocoon the silkworm goes through the last phase of its larval life. After four or five days the skin breaks, and the insect which

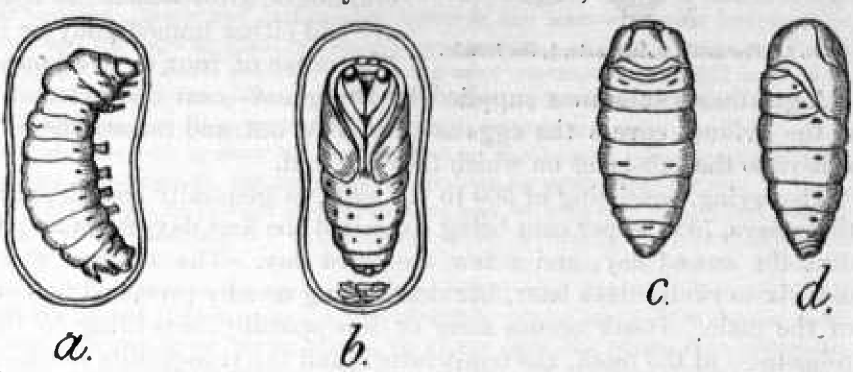

FIG. 3.—The chrysalis: *a*, silkworm completing its cocoon; *b*, cocoon and chrysalis—cast-off skin of larva beneath; *c*, back view of chrysalis; *d*, side view of chrysalis. (Redrawn from Maillot.)

issues from this old covering is the chrysalis, whose weight is often only half that of the larva at its highest development (fig. 3)

The chrysalis seems to have neither head nor feet, is golden-colored at first, and then turns chestnut brown. The skin dries rapidly and forms a hard case, on which the lines of only the posterior rings are seen, the place of the first three rings being covered with the wing-cases.

The chrysalis state is in certain respects a sleep and in others a period of great activity, in which the entire being is transformed. Wings, antennæ, reproductive organs, and legs are all now developed. This state lasts from eighteen to twenty days, according to the temperature. When the metamorphosis is complete, the sheath breaks in the region of the head and the moth or perfect insect issues.

THE MOTH.

The larva in spinning the cocoon leaves one end less dense, so that the threads open freely to permit the egress of the moth. By the aid of an alkaline fluid the moth softens and parts the threads and liberates itself.

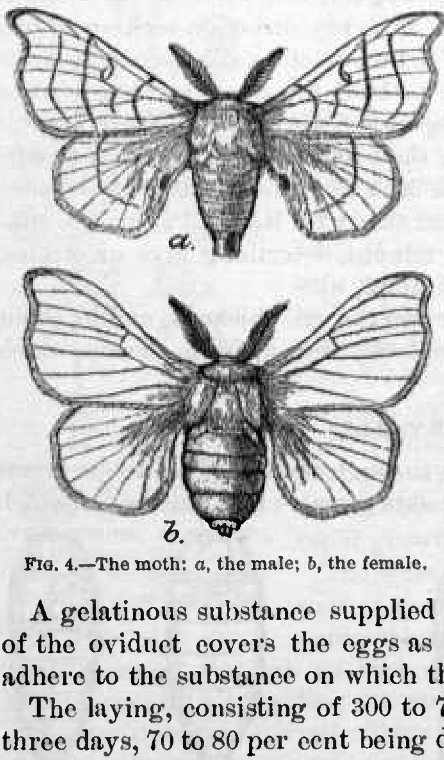

FIG. 4.—The moth: *a*, the male; *b*, the female.

The moth (fig. 4) comes out of the cocoon, as the larva out of the egg, in the early morning hours. It has a distinct head, thorax, and abdomen, four wings, two comb-shaped antennæ, three pairs of legs, and a pair of compound eyes.

Shortly after emerging, the moth deposits a liquid substance, generally white, sometimes colorless and sometimes reddish, and then the union occurs, lasting several hours, after which the eggs are laid either immediately or in the course of four or five hours.

A gelatinous substance supplied by two glands near the extremity of the oviduct covers the eggs as they come out, and causes them to adhere to the substance on which they are laid.

The laying, consisting of 300 to 700 eggs, is generally completed in three days, 70 to 80 per cent being deposited the first day, 20 to 30 per cent the second day, and a few the third day. The mother moth dies six to twelve days later, her death being usually preceded by that of the male. Death occurs more or less speedily, according to the robustness of the moth, the temperature, and the tranquillity in which it has been left.

Thus in about sixty-five days the silkworm has completed its cycle of existence, its three periods being thirty to forty days in a larval

state, fifteen to twenty days as a chrysalis, and eight to twenty days as a moth or perfect insect.

The rapid development of the silkworm and its marvelous transformations indicate extraordinary power and very active functions. Its respiration is almost equal to that of the frog and of certain large birds, and it must be always surrounded by plenty of pure air.

THE FOOD OF THE SILKWORM.

The leaf of the white mulberry is the natural and the best food for the silkworm. There are many varieties of the white mulberry—some much better adapted than others to commercial silk culture, and some better suited to certain localities.

CULTURE OF THE MULBERRY.

As the securing of a food supply is a necessary condition to silkworm culture, some information on the culture of the mulberry, condensed from a bulletin of the Bureau of Plant Industry, [a] is inserted:

Of the mulberry there are many so-called species and a great many varieties, but there are only one or two species and a few varieties which are of importance in silkworm propagation. Chief among these for producing silkworm food is the white mulberry, *Morus alba.* This is thought by some to be a native of China. It is hardy over a large area of the United States.

Most of the silkworms reared in China are said to be fed upon *Morus multicaulis.* This mulberry was largely planted in the United States many years ago. Few, if any, of the original trees remain, but specimens which are thought to be wild seedlings of these are very plentiful in the Southern States. These trees are thoroughly acclimated and free from disease. It is therefore probable that there is now in the United States an abundant supply of material for propagating purposes, at least. The white mulberry, under good cultivation, is a low-growing tree, seldom attaining a greater height than 25 or 30 feet. It will reach this height in a comparatively few years after planting. In the vicinity of Washington the trees flower about the middle of May and ripen their fruit during June.

The mulberry may be propagated by means of seeds, cuttings, layering, grafting, and budding. Seeds and cuttings are, however, the least expensive and troublesome, and the most satisfactory means of propagation.

Propagation by Means of Seeds.—This is the most convenient and rapid method of propagation. To remove the seeds from the berries, place them in a large bucket or a tub and squeeze them with the hands until they form a jelly-like mass. Add water and stir well to allow the seeds to sink to the bottom. The water and pulp can then be poured off, and the seeds can be dried by exposure to the air.

The seeds may be planted at once, or they may be kept over winter and planted in the spring. Beds about 5 feet wide should be thoroughly prepared. The seed should be sown broadcast, not too thick, as crowding makes weak plants. Press the seeds in with the back of a spade and cover lightly with fine soil. For protection from the heat of the sun, over the beds should be placed lattice-work screens made of lath, and over these canvas should be spread until the plants show above the ground. After that the canvas is unnecessary except in the hottest part of the day. With spring-sown seeds the lath screens without canvas will be sufficient.

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[a] Bul. No. 34, Bureau of Plant Industry, U. S. Department of Agriculture. By George W. Oliver.

Seedlings vary considerably from the parent tree, and many of the seedlings grown will be found to have leaves of undesirable quality. Hence careful selection should be practiced and many of the seedlings must be rejected.

The Use of Cuttings.—For propagation by means of cuttings in the summer time, selected seedlings which have made considerable growth may be used. Two or three leaves clipped to half their length should be retained on the cutting (fig. 5, *a*.) The cuttings should be set sloping in beds of moist sand in a cool propagating house, or, if such is not available, in a cold frame with northern exposure; if in the shade of trees, so much the better. The sash should be kept closed to conserve the moisture of the atmosphere until the cuttings have taken root. When considerable root growth has been made they should be transferred to beds in the open, being placed 6 inches apart each way and well watered until established.

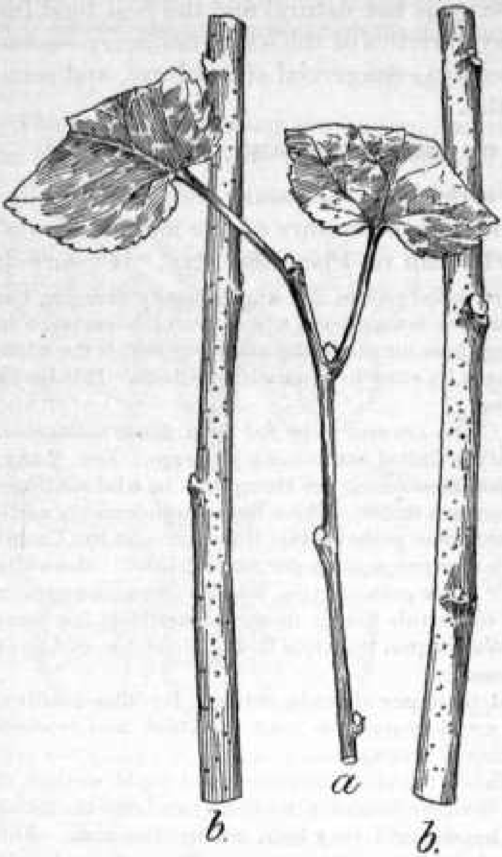

FIG. 5.—Mulberry cuttings: *a*, a summer cutting; *b*, *b*, winter cuttings.

The supply of winter cuttings should come from dormant wood taken from the trees just after the leaves have fallen. The cuttings (fig. 5, *b*) should not be less than one-fourth inch in diameter and should be about 10 inches in length, the top cut being made about a half inch above a bud. The cuttings should be tied in bundles of 50, and these may be buried in moderately moist sand or ashes until spring, when they can be put out in rows in well-prepared soil. These nursery rows should be well cultivated and kept clear of weeds.

Another method of propagation from cuttings, and a very successful one, consists in selecting medium-sized shoots about the beginning of November. These, before being made into cuttings, are sorted into bundles of different lengths, tied, and heeled in ashes or sand, or in a mixture of both, and protected by a frame having a northern exposure. During the winter they are taken out and cut into lengths of about 5 inches. These are tied in bundles and buried in moist sand or moss. In early spring they are untied and put quite thickly in a propagating bed having a mild bottom heat, where they will root rapidly. When such a bed is lacking, wooden flats about 4 inches deep may be used, but they must have the protection of a frame covered with sash. If a little loamy soil is placed in the bottom of the flats the cuttings will remain in good condition for a considerable time after rooting and until a favorable opportunity arrives for planting them out in nursery rows.

Planting.—The mulberry grows well in a great variety of well-drained soils. The young trees should be transferred from the nursery to their permanent places either

in the fall or in the spring. If in the fall, the transplanting should be done when the leaves have matured or fallen. In the spring transplanting may take place as soon as the ground is in good workable condition. The ground should be deeply plowed and thoroughly harrowed. If the ground is hard and the soil poor, large holes should be dug and filled with good soil as the trees are planted. In transplanting the roots should never be allowed to get dry. When taken up they may be immediately dipped in a mixture of soil and water and then kept covered until planted.

The distance between the trees should not be less than 10 feet each way. If the grove is to be large, wider spaces should be left at intervals, so that wagons may be driven through.

Pruning.—Pruning is best done in the fall or winter. The central part of the tree should be kept open to admit light and air. The low, spreading form of tree is much the best, and this form is secured by systematic pruning, which is begun by cutting the young tree back one-half in the fall after it is first planted out. Afterwards three or more strong shoots should be selected to form the main branches, and, if necessary, these may be prevented from growing upright by means of sticks fastened between them in such a way as to force them to spread apart.

In gathering the leaves always allow enough to remain on the tree to insure its perfect health. If some of the trees show signs of failing vigor as a result of excessive leaf gathering, it is advisable to allow them to grow for a season without picking, and by early pruning out of unnecessary growth permit those growths which are desirable to become ripened.

Restricting the height of the trunk of the mulberry to 5 or 6 feet makes it possible for old women and children to gather leaf, thus diminishing the cost of labor one-half, a most important point in commercial silk culture.

It is also important to cultivate trees that bear little or no fruit, for the production of fruit not only consumes part of the strength of the tree, but much labor is involved in being compelled to divest the branches of fruit before they can be used as food for silkworms.

The stump mulberry, or that growing low like a shrub, the hedge mulberry, and that which grows along walls vegetate much earlier than the medium and high trunk trees. Silkworm rearers should always have a ready supply of leaf for the first ages of the worm, and especially is this necessary if early cultures are desired with a view to escaping the heated days of May and June.

AMOUNT OF LEAF AND PREPARATION.

The race, the size of the worms, the variety and age of the mulberry, the nutritive quality of the leaf, the year, the season, and the climate make the requisite quantity of leaf very variable. The following is given as a basis of calculation, all circumstances being considered, and the leaves not being cleaned: For the larvæ hatching from 1 ounce of eggs, during the first age, 11 pounds of leaves; during the second age, 26 to 33 pounds; during the third age, 88 to 145 pounds; during the fourth age, 264 to 352 pounds; during the fifth age, 1,540 to 1,760 pounds; or about 2,200 pounds in all, of which one-half is consumed in the last six or seven days of the fifth age.

The age of the leaf should be relative to that of the worm. Young worms fed on old leaf, or old worms fed on young leaf, are apt to become diseased, and even though they may not die, will scarcely molt or will spin indifferently. A change of leaf, too, should, if possible, be avoided, or made gradually. Fresh leaf only should be used, and never when wet with dew or heated, or before it has in a measure acquired the temperature of the room in which the worms are being reared. It should be gathered early in the morning or in the evening and should not be bruised or torn, nor should the baskets or aprons used to carry it be the same which are used to remove litter. To avoid fermentation the leaves must be spread out in a cellar or cool, darkened room. Cut up only a limited quantity of leaf at a time and cover with a damp cloth to keep fresh, but never submerge the leaf in water, as this is apt to occasion flacherie, a very destructive disease. From the fourth age on there should always be a day's supply ahead, so that in case of rain the worms will not have to fast.

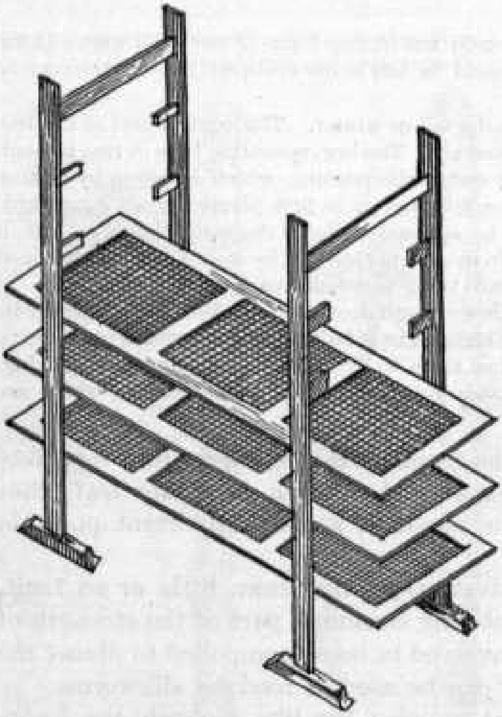

FIG. 6.—Light movable shelves.

In gathering leaf, always strip the branches from base to top, so as not to tear the bark and injure the new buds. The sacks for holding the leaves should have a hoop around the opening and a hook to suspend them to the branches.

IMPLEMENTS NECESSARY TO SILKWORM CULTURE.

Commercial silk culture requires a smaller outlay of capital than almost any other industry. The net gain the first year may pay for an outfit which will last for many years. The following articles are indispensable:

(1) Some very light movable shelves, open to air, for the first ages; and, for the following ages, latticed shelves about 3½ feet wide, and stands to support them.

(2) Unsized ordinary wrapping paper or newspapers to cover the shelves.

(3) A small ladder, if necessary, to reach high shelves.

(4) Small trays to remove worms.

(5) Knives to cut leaves and baskets to distribute them.

(6) Coarse tulle and nets or perforated paper for changing beds and equalizing the worms.

(7) A supply of brush, straw, or shavings to construct the spinning place.

(8) A thermometer.

Wire, twine, laths, or canes are suitable for the lattice work of the shelves. Make the space between the shelves about 14 inches. If

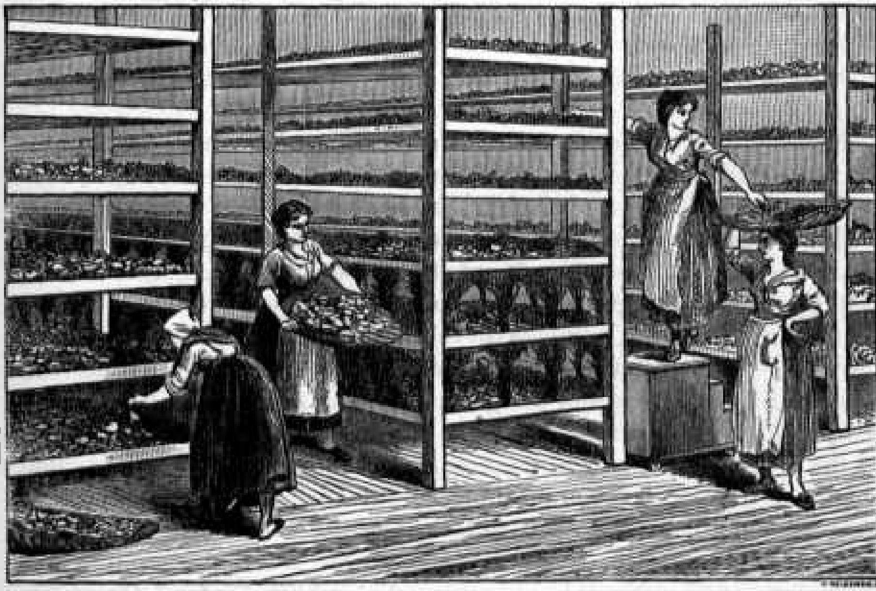

FIG. 7.—The rearing room (after Gobin).

possible, do not arrange the shelves along the wall, and allow a good passage between the tiers of shelves (figs. 6 and 7).

SILKWORM EGGS: HOW TO WINTER AND HATCH THEM.

There are two kinds of silkworm culture: One for production and one for reproduction. The object in the first case is to get the greatest yield of cocoons, and with a little training, may be carried on by anyone of ordinary intelligence.

The object in culture for reproduction is to secure eggs free from hereditary taint of disease, and experts only can be depended on to conduct it. Besides a careful physiological examination throughout the rearing, the body of the mother moth is microscopically tested after death, and her eggs are not retained if signs of disease are discovered. In this way the birth of healthy worms is insured. Pasteur first applied this method of selecting silkworm eggs, and thus checked the plague (pebrine) which was rapidly destroying silkworm culture in Europe.

Formerly, through an indiscriminate use of eggs, disease invaded the rearings to such a degree that from 65 to 90 pounds of cocoons was considered a good yield per ounce of eggs. At the present low price of silk such cultures are no longer remunerative, and industrial silk culture now demands the exclusive use of scientifically tested eggs.

The grainage, or preparation of eggs for market, constitutes a special department of silk culture. In Italy there are over 400 establishments which supply eggs to raise the annual silk crop. The poorest peasant, though well skilled in the art of rearing silkworms, would not risk a rearing with eggs which have not been selected and preserved by experts.

The eggs of crossed races are best for culture with a view to production of silk, and here, as much as in the examinations which have been referred to, the knowlege of experts is needed.

The life of the egg, in those races which have but one generation each year, has three phases, the first lasting about three months, full of activity; the second lasting from about October to the middle of February, one of inactivity, in which there are no signs of life; the third from the middle of February to the moment of hatching, in which the vital activity recommences, and the germ begins to organize as soon as the temperature rises a little above 50° F. The measure of the activity of the egg, in this stage, is the measure of its danger, for any sudden change of temperature would injure or destroy the delicate embryo, or cause the larva to be born before its food was ready. To guard against such accidents, eggs must be wintered in a high region or in a refrigerator at a uniform temperature of about 35° F., from December 15, until the mulberry begins to bud or until hatchings are desired. There should always be good ventilation, the air should not be moist, and great care must be taken to keep the eggs out of the reach of mice and insects.

Natural hatchings are almost always irregular, extending over eight or ten days, thus multiplying the divisions and rendering the rearing difficult and costly; hence, the necessity for artificial incubation.

Eighteen days before the time decided on for the hatching, spread out the eggs in thin layers in the incubating room or incubator. The temperature should be 55° F.

From the fourth day on, gradually increase the temperature two degrees in twenty-four hours until 73° F. is reached, when, at this uniform temperature, hatchings will occur in ten days on an average. This period, however, varies from eight to fifteen days, according to race, the cold supported during the winter, the first grade of heat, and the highest during the incubation, and the number of days taken to pass through these two grades of heat; and also according to the humidity. To obtain a good and complete hatching, a slight humidity

is necessary, especially during the last four or five days. To secure this keep an open vessel of water near the fire, or sprinkle the floor with water occasionally.

The temperature may be raised during the hatching to 75° F., but sudden changes of heat must be avoided, and, unless the newborn worms can be kept in the same temperature, it is dangerous to have the maximum temperature of the incubator so high.

It is better for the period of incubation to be protracted than suddenly shortened. Holding the eggs at a certain temperature, or slowly lowering the temperature a little does no harm. When the season is not propitious, the hatching may in this way be retarded.

An incubating room is preferable, because it also serves for the first two stages of the worms, but in small rearings an incubator is more economical, both with regard to service and to fuel.

For a large quantity of eggs (5 to 10 ounces) a small incubator, which is very much used in chemical laboratories to dry substances, is recommended. Any ordinary tinsmith can make it. It consists of a double case, cubical in form, with a zinc bottom. The space between the outer and inner walls is filled with water. The front face of the cube is furnished with a glass, so that the temperature within, indicated by the thermometer hanging on the glass, may be seen without the necessity of opening the incubator. There are two openings below on opposite sides to allow the cold air to come in, and an opening in the center of the top to permit the outward flow of the heated air. Having filled the space between the walls with water through the pipe, the incubator is placed on a support and heated by means of a gas or oil lamp to the desired degree, and, by raising or lowering the flame, a constant or progressive temperature can be maintained (fig. 8). A self-regulating incubator, such as is used to hatch chickens, would be more convenient, but would cost more.

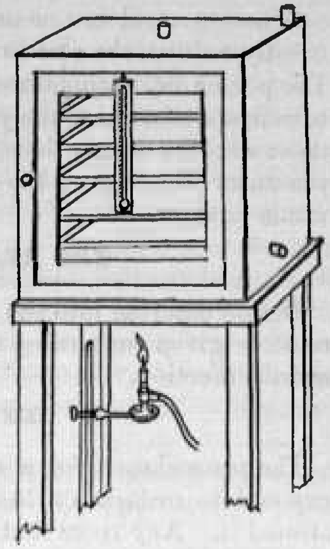

Fig. 8.—Hot water incubator. (Redrawn from Verson and Quajat.)

The whitening of the eggs denotes the near approach of the hatching. Double pieces of tulle or sheets of perforated paper sprinkled over with finely cut-up white mulberry leaves should then be lightly placed over the eggs to allow the outward passage of the worms as soon as hatched. The object in employing two pieces of tulle or paper is to prevent the unhatched eggs which cling to the sheet from being removed with the newborn worms. This process must be

repeated daily during the hatching, the second sheet always being renewed.

The duration of the hatching varies from three to five days, the eggs hatching about as follows: During the first day, 5 per cent; during the second, 33 per cent; during the third, 50 per cent; during the fourth, 5 per cent; during the fifth, 7 per cent.

Twenty-five grams of eggs will give about 17 grams of worms. In small rearings most cultivators raise only the worms that are hatched on the second and third days, to avoid the necessity of forming too many classes. The worms must be classed according to the date of birth, and the insignficant number hatched on the first and last days scarcely compensate for the trouble of rearing them. Different races must also be reared separately.

Where several in one neighborhood are engaged in silk culture it greatly reduces the cost to have all the eggs hatched in one incubator. The person best acquainted with silk culture can undertake the incubation, and distribute the young worms on the second or third days to those who are to rear them. This is the plan adopted among the Italian peasantry, the wife of the supervising farmer hatching the eggs for whole villages.

THE REARING OF SILKWORMS.

Before entering into the details of a rearing some general directions must be given concerning the rearing room—the heating, ventilation, and disinfection.

GENERAL DIRECTIONS.

The place chosen for a rearing should be relatively high, and not exposed to malaria or bad odors, and mulberry trees should grow around it. Any room that can be properly heated and ventilated will answer the purpose. An open fireplace is the best means of heating, but is expensive, as much of the heat is lost. Hot-water pipes, such as are used to heat a greenhouse, are good for a building specially built for silkworm rearing. Iron stoves should not be used, unless placed in an adjoining room with communicating pipes. Never employ charcoal as fuel.

Ventilation.—The domesticated worm should be surrounded continually by pure air. The amount of carbonic-acid gas given out by the worms and their attendants is very considerable; besides this, a quantity of deleterious gas is generated by the litter of the beds, and the lights and fires consume a great deal of oxygen. Myriads of spores and germs of organic life float in the air of the rearing room, and their influence paralyzes the vital energy of the skin and of the organs of respiration, on whose normal functions the robustness of the worm so much depends. Hence, it is evident that the quantity of

vitiated air which should be expelled from the room requires the introduction of a large quantity of fresh air. For this, a double system of ventilation is necessary, which may be obtained by double openings in the windows, to allow the heated bad air to pass out above and the cool fresh air to come in below. To renew the air in every part of the room, and to avoid a single and often violent current, there should be more than one window. An open fireplace is the best means of ventilation. When the difference between the external and internal air is slight, or there is no difference at all, artificial means must be used to create a current. Light and frequent fires, or a burning lamp in the fireplace, or a revolving fan, may be used to prevent stagnation of the air.

Disinfection.—Eight or ten days before introducing the worms into their quarters all the shelves and implements should be washed in a solution of chloride of lime (11 pounds of chloride of lime to 88 quarts of water), or in a solution of sulphate of copper (1 to 100 by weight).

When everything is in order—tools, perforated paper, material for the worms to spin their cocoons on, etc., each in its own room—close the doors and windows as tightly as possible and fumigate the rooms with sulphur (11 pounds of sulphur to every 100 cubic yards of space). To fumigate properly, powder the sulphur and place it in an earthen or metallic vessel over a slow fire. The sulphur will gradually melt and take fire. Place it immediately in the rearing room and leave it, with the doors and windows completely shut, for twenty-four hours.

Nets should not be exposed to sulphur fumes, for this would soon rot them, but should be washed in a solution of sulphate of copper, and immediately afterwards in plain water.

Twenty-four hours after the fumigation the floors should be washed with a solution of chloride of lime or sulphate of copper, and the walls should be whitewashed with lime.

When dead worms are seen on the shelves, change the beds and create in the rearing room sulphurous gas by burning a pound of sulphur during six hours, or make a strong wood smoke, which is a good disinfectant and will not harm the worms.

Precaution having been taken to destroy germs of disease in the rearing room, the new-born worms may now be safely installed there.

Space Required.—The worms from 1 ounce of eggs should cover at birth 1 square yard. Doubling this space on the fourth day, they would require 2 square yards, and at their change of beds after molting, 4 square yards. By the spacing of the third day of the second age, and the doubling of beds preceding the second molt, they will need for the second age 8 square yards. For the third age 16 square yards will be required; for the fourth age 32 square yards; and for the fifth age 60 square yards. The more space that is accorded to the

worms in their first ages, the more robust they will be; and if the space can be tripled instead of doubled during the fourth age, and for the fifth age be 70, 80 or 90 instead of 60 square yards, the harvest of cocoons can be raised from 60 kilograms to 70, 80, or 90 kilograms per ounce of eggs, the quality of silk also being superior.

Temperature.—The silkworm is not a tropical insect, and attains its best development between the temperatures of 68° and 77° F. It is safe to adopt the mean between these two temperatures for the general rearing. Each cultivator, however, may suit his convenience, remembering that to fall below or to exceed the mentioned limits of heat is detrimental to the worm, and will affect the quantity and the quality of its spinning.

From the second age the temperature should be from 70° to 72° F. and should be kept as uniform as possible to the end of the rearing. The time which elapses between one change and the following one may be much shortened by raising the temperature and feeding oftener. Such hasty rearings may be made in twenty-two to twenty-four days. They are, however, to be condemned, as contrary to the nature of the silkworm. Meals following each other too closely can not be properly digested, and are likely to cause disease. Besides, hasty rearings require more labor, and the service must be kept up night and day. As there is danger in too high a temperature, so there is danger in one that is too low (64° to 68° F.). A rearing that is too prolonged, lasting over thirty-two days, is to be avoided to escape the heat of June, under which the beds are more likely to ferment, causing disease; the worms have less appetite and leave more leaf from one meal to another; the changes are slower and less likely to occur instantaneously; and there is more risk of muscardine or calcino, a disease due to a mold.

Both hasty and tardy rearings are, therefore, to be proscribed, and those conducted in twenty-eight to thirty-two days alone are recommended. This lapse of time permits the leaves of the mulberry to acquire maturity, and the growth of the worm should be relative to that of the leaf on which it feeds.

THE FIRST AGE.

Hatchings usually occur early in the morning. The worms which have crawled up through the holes of the tulle or paper to get food, should not be removed before 10 a. m. to the latticed shelves covered with paper to receive them. Each shelf must be marked with the date of the birth of the worms put upon it, and care must be taken to place on the same shelf only worms born on the same day, as a remunerative rearing demands that such alone be raised together.

Should the hatching occur at 68° to 70° F., keep this temperature during the first ages, and feed eight times during twenty-four hours; if

the temperature at birth is 75° to 77°., slowly diminish the temperature one or two degrees, and feed ten times in twenty-four hours. The appetite of the worm increases or diminishes with the heat. The second day, in case of the worms hatched at the maximum, adjust the temperature to the degree proposed to conduct the rearing. In feeding sprinkle finely cut up tender leaves frequently over the worms, and toward the fourth day begin to regulate the number of meals so that it will range from four to eight, according to the temperature. Before cutting the leaf remove the stems. Distribute the leaf uniformly and equally on the shelves, in order to prevent the worms from crowding more on one side than another, and in order that they may be equally nourished and make their changes simultaneously. Cut only a small quantity of fresh leaf at a time, and keep the rest in jars or baskets covered with a damp cloth. Never submerge the leaves in water. For the first two or three ages, the white ungrafted mulberry is recommended, it being lighter and more digestible for delicate worms.

It is well during the feeding to open the door and windows to insure a good supply of fresh air. After feeding, close the door and windows, unless the day is warm, when they may be permanently left open, protected by curtains through which the air passes freely. The worms should never be exposed to direct sunlight or to a strong current of air, and during a thunderstorm the windows and doors should be closed.

Worms of the same age and development should be classed together. To obtain this equalization, do not feed newborn worms until all that have been hatched on one day have been removed to shelves, then give a general meal. If at the end of two or three days it is noticed that on certain shelves there are smaller worms than on others, in order to allow the less developed worms to catch up with the more advanced ones, place the former nearer the fire or on the highest shelves, where the air is warmer, and give them one or two more feeds than the larger worms. For this reason it is well to have light movable shelves.

Many cultivators of silkworms do not change the beds during the first age, and it is not absolutely necessary, if the leaf has been well cleaned of stems and very finely cut up, and, above all, if the air is dry. Change of bed, however, must be made if the litter is damp, and the weather rainy, for the worms are going to molt in two or three days, and this crisis should not occur in unhealthy conditions. It is always more prudent to change beds on the fourth day, and is, therefore, advised. The space occupied by the worms must be doubled when the change of beds is made.

The bed on which the leaf and excrement accumulate is, perhaps, the greatest source of danger to the worms. When there is not a free circulation of air, gases are developed which almost always cause fermentation, paving the way for future disease. Hence the necessity for frequent change of beds. This is made in various ways. The

practice of doing this by hand is to be condemned because it consumes too much time and is apt to injure the worms. Thread nets (fig. 9) and perforated paper are the best means to employ. They save two-thirds of the hand labor, and thus allow beds to be oftener renewed, which is a most important consideration. In the first age tulle or mosquito net may be employed instead of nets or paper.

The manner of proceeding is as follows: Place the last meal at night on the nets and extend them over the worms. By morning the worms will have mounted above the opening in search of fresh leaf. Then lift up the nets, beginning at the top shelf, and place them on clean shelves. Carefully detach from the nets any portion of the old bed, and, if the worms are not molting, gather up the few worms that have remained behind, and tenderly place them with the others. The change of beds is thus rapidly effected with the least labor.

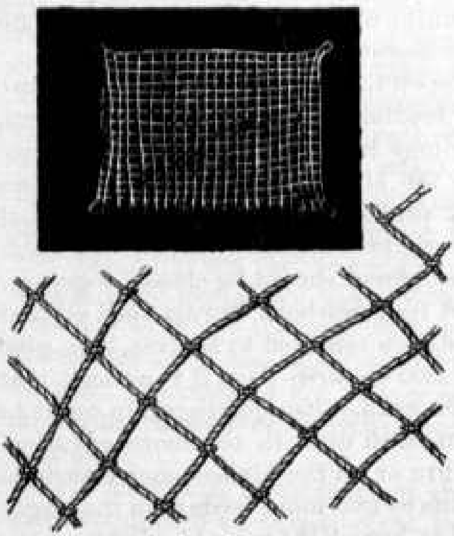

FIG. 9.—Net used in changing beds.

It is very important that the tension of the net be such as to prevent the worms from being crowded together in the middle.

Perforated paper (fig. 10) is another means often used to effect change of beds; but it does not allow the worms to mount with the same facility. It is also apt to break when the worms become heavy, and in many cases it has to be renewed annually, so, in the end it is no cheaper than nets.

In changing beds, do not feed the worms that are first taken up until all from the old bed have been removed; then give a general meal, for all the worms born on the same day and forming one class should have the same number of meals to preserve their equality of growth, which is necessary for a successful rearing.

Having adopted hours for feeding, these should be adhered to throughout the rearing. When four meals are given, the best hours are 5 to 6 a. m., 10 to noon, 3 to 6 p. m., and 9 to 11 p. m.

Toward the sixth day worms begin to eat less. This is a sign that they are going to molt. Then another change of beds and doubling of space are necessary.

The molt or change of the worm is easily recognized by a swelling of the head, whitening of the skin, transparency of the body, and a fixed position.

To change the beds, proceed as before, only leave undisturbed on the old beds the worms that are molting. When all the tardy worms have been taken up and placed on shelves, give them frequent sprinklings of finely cut up leaf to enable them to catch up with the worms already molting. Diminish the feeding as the backward worms begin to molt, and cease feeding entirely as soon as a single worm comes out of the molt. Then wait twenty-four hours so that the worms may be well over the change before giving a general feed. In this way the equality of development necessary for a methodical and successful rearing is maintained. A fast of twenty-four hours will not hurt the advanced worms, while the extra feeding given to the backward ones may enable them to become equal to the former.

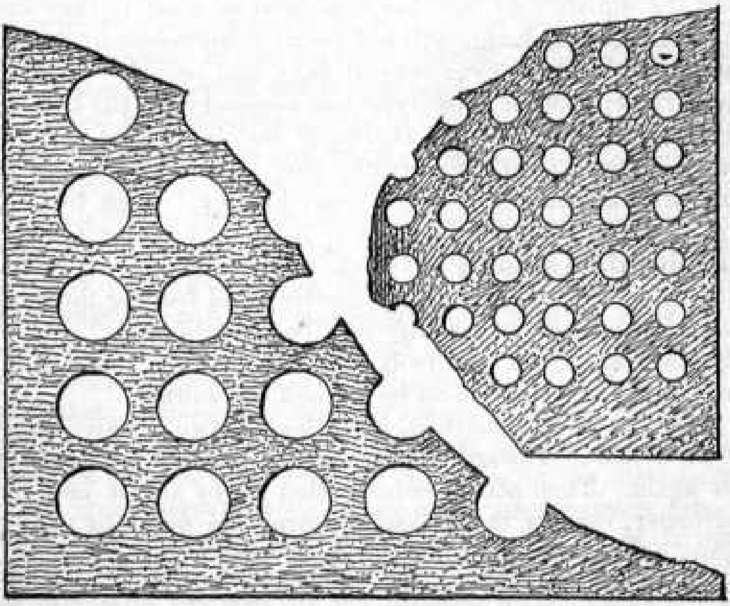

FIG. 10.—Perforated paper used in changing beds in the second and third ages.

The beds or the worms on the old litter may be changed when the general meal is given.

Many cultivators do not change the beds and double the space until after the first molt, allowing all the worms to change in the same bed. In this case, owing to the distribution of leaf for one or two days after the molting has begun, the molting worms are covered by a more or less thick coat of litter, and exposed to emanations of bad gases in a critical period of life, which is likely to cause disease. Besides, in the first age, the worms are so small that they are likely to be lost in the litter, or to perish from suffocation. Hence, it is healthier to change beds and double the space before the molt.

THE SECOND AGE.

The coming out of the molt is announced by the appearance of a small triangular-shaped livid spot on the worm's head, and the changed skin is grayish in color. The worm takes several hours to recover from a change; then it begins to search for food, which, however, as before stated, must not be given before all the worms have recovered from the molt. Then a slight meal is given by means of perforated paper or nets. The worms crawl up promptly and can be easily gathered up and placed on fresh shelves.

If the two sets of worms recover from their molt at the same time, they may be classed together; if there is a difference of a day, it will be necessary to keep them separate throughout the rest of the rearing, for the equality of age has disappeared, and, if they are put together, the second change will not occur simultaneously for all the worms, but will extend over several days, and occasion the greatest trouble to reestablish the equality of size necessary for the best results.

In case no worms have had change of bed before the molt, do not recommence feeding until the greater part of the worms are awake. Do not fear that they will suffer from hunger. Then form a new division of those still molting. It is frequently better to have two divisions, but if, to simplify the work, but one is desired, by putting the backward worms on the highest shelves, and feeding them oftener than the advanced set, an equality may be reestablished.

Three days after the first molt the beds must be renewed, and at the same time more space must be allowed the worms.

The second age is the shortest, being less by two or three days than any of the others. Toward the fifth day of this age the worms begin to molt again. Then act as before—that is, by aid of nets or perforated paper, remove the backward worms, in order to place them elsewhere, and try by more heat and abundant food to make them catch up with the forward worms.

THE THIRD AGE.

When the worms are over their second molt they cease to be gray, and take the characteristic color of their race. If they are too long in molting it is because the temperature is too low; that is, below 68° F. Increasing the heat a few degrees will excite the worms and enable them to complete their change. After this the temperature adopted for the rearing must gradually be resumed.

The worms double their size in their third age; consequently the space allotted to them must be doubled; that is, they must have 16 square yards instead of 8 square yards, as in the second age.

From the second to the third molt the same care is to be given as has been prescribed for the first two ages, except that, if a small incubating room has been used instead of an incubator, the worms must

now be transferred to a larger room to complete the rearing. Care must be taken to heat this room the day before to 80° F., and the next day lower the heat to the degree adopted for the rearing. Feed six times daily either with whole leaves or leaves which are coarsely cut up. For this as well as all the other ages the best rule to follow in feeding is to give only a light sprinkling of leaf at the beginning and end of each age, gradually increasing the ration up to the middle of each age, and then diminishing to the time of a molt. The appetite of the worm will serve as a guide. Give more or less leaf according as the preceding meal has been more or less eaten. In this way leaf will not be wasted and a large quantity of litter will not accumulate under the worms, to their detriment.

Toward the sixth or seventh day of the third age, according to the temperature, the worms begin to be languid and lose appetite, as before, and are ready to make a third change. This is the most difficult of all and the one in which they seem to suffer the most. It is also the period when diseases due to bad eggs or to a poor incubation are developed. Excepting accidental diseases, a good result may generally be predicted if the third change is safely passed. With these facts in view, from the beginning of the third age keep the worms sparse on the shelves and see that the beds are dry and changed with scrupulous care, the litter being far removed from the rearing room. Avoid feeding with wet leaf, and to favor the molting raise the temperature a degree. It will be noticed that the head and body of the worm are more swollen than in other molts. It is this superabundance of liquid that renders this molt so critical and necessitates a drier atmosphere and a bed which is very dry and not apt to ferment.

The worms increase three times in volume after the third molt, and must have space accordingly. They must be separated into three divisions in the following manner: Instead of waiting, as in the first two changes, until half of the worms have begun to molt, let down the nets, or otherwise prepare for the removal of the backward worms when one-third or even less of the worms show signs of molting. About two-thirds will then crawl up on the fresh leaves, and must be placed on a shelf where, after one or two meals, they proceed to molt, being again divided after the first or second distribution of leaves, according to the rapidity of the molting.

If only a few worms mount when the first division is made, the operation was delayed too long, and it is unnecessary to divide those first taken up; but after the change the division of those left on the old bed can be made. To allow the worms to spread out, each division should occupy but one-third of the shelf on which it is placed.

THE FOURTH AGE.

When all the worms have molted the third time a change of beds must be made as in preceding ages. Do not be in haste to change.

Wait a few hours to permit the worms to recover their strength a little. The recommendation to feed lightly at first applies especially to the beginning of the fourth age.

If the outside temperature is normal, fires need not be kept up, and the doors and windows may be left open, guarded by light curtains. In this age the worms eat enormously and more help will be required to gather and distribute leaf. Small branches of leaf may now be given in place of whole leaves, and the number of meals may be reduced to four, if the temperature is 68° to 70° F., at which temperature the age will last nine days. If it is desired to reduce this age to seven or eight days, raise the heat to 72° F., and give five or six meals daily. Should change of weather retard the growth of the mulberry trees, and temporarily cut off the supply of leaf, adapt the rearing to such a contingency by lowering the temperature slowly to 66° or 68° F., and giving only three or even two meals daily. Then, when leaf is obtained, gradually raise the temperature to the degree adopted for the rearing.

During the fourth age four changes of beds are made, including the one which follows the third molt. A single division of the worms is sufficient, which will be the last, and particular care must be taken to divide the worms into two equal parts. For this, spread the nets or perforated paper over the worms when half are molting and proceed as before.

THE FIFTH AGE.

Do not be in haste to change beds as soon as the worms have molted. This precaution is necessary to allow the new organs to acquire consistency, and to prevent worms from being lost in the litter. Consequently, wait several hours, and change beds after the second meal, the first being only a slight sprinkling of leaves. Worms are not strong enough immediately after a change to digest a heavy meal.

The space during this age should not be limited. See that between two worms another could be easily placed. Experience has proved that the harvest of cocoons is often in proportion to the space accorded to the worms during this age.

Feed from four to six times daily, according to the temperature, and spread the branches or leaves out regularly, not to form a mass. For a simultaneous mounting into the brush all the worms should eat an equal quantity of food.

As ripe berries are very indigestible, and also cause beds to ferment, care must be taken to shake the trees well before gathering the leaves, and whatever ripe fruit remains must be taken off before feeding.

If possible, change beds daily, especially if more than five meals are given, or if the weather is very warm and damp and there are signs of disease.

The first five days after the change the worms grow enormously, and it is very difficult to satisfy their appetite. At the end of this

time the body suddenly diminishes in circumference, the excrement, formerly dry and firm, now becomes moist and soft, and the appetite diminishes and becomes capricious. This state generally lasts three days, then suddenly the worm ceases to eat, and tries to get away from its food. It prolongs its head, and, changing its former lazy habit of scarcely moving except to get food, runs about in every direction, stopping from time to time, and moving its head (now transparent gold or white, according to race) like a blind person seeking the way.

These signs indicate that the worm is hunting a convenient place to spin its cocoon. The worm is now mature, and a spinning place should be ready to facilitate its metamorphosis. The humidity, which always exists at this time on account of the mass of litter, is especially dangerous to the worms; and it is increased if the worms do not all mature and mount at the same time, for those that remain below are wet by the liquid dejections of those that are the first to mount. For this reason do not put worms in the spinning place until they are perfectly mature. They then mount, and crawl around some time seeking a favorable place for their cocoons. Finding this they evacuate their digestive canal, and begin to throw around them an irregular net in which the cocoon spun later will be suspended.

PREPARATIONS FOR SPINNING.

A considerable loss may occur in the spinning place even when the rearing has been most successful. To avoid such loss observe the following precautions: (1) Prepare the spinning place in time; (2) arrange it so that the worms may regularly mount, and have abundant room; (3) have it well made, yet economical; and (4) regulate the heat and ventilate the room.

Any convenient dry bushy brush, odorless and free from gum, will serve to construct the spinning place; or if such is not available, bundles of straw, or shavings, or finely split up wood may be substituted. The best and most economical arrangement is small bundles of brush or straw placed upright between the feeding shelves, in rows, about 16 inches apart. The bundles are cut a half inch taller than the space between the shelves, and their tops are spread out to form arches, and to allow the worms plenty of room to spin (fig. 11).

Branches of elm, oak, birch, etc., are used to place the worms in the spinning place. These branches are spread over the shelves at the end of the fifth age. Very soon they will be covered with mature worms which have ceased to eat, and are turning away from the mulberry. In this way it is easy to select the worms that should be transferred.

If the worms are equally developed, in thirty or forty hours they will be shut up in their cocoons. The few that remain behind should be placed elsewhere; fed with fresh leaf on clean beds they will soon catch up with the others.

The fifth day after the mounting the worms that have not begun to spin should be placed in bundles of twigs and covered with straw or leaves, or put in a basket of shavings, where they will be forced to spin.

The temperature during the spinning should be 75° F., and the humidity throughout the rearing about 65°. A good practical test of

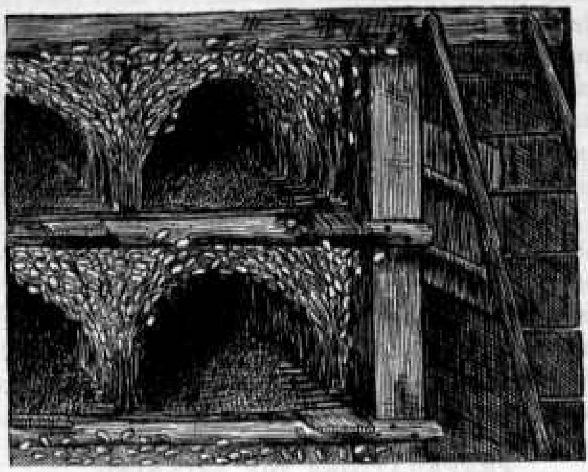

FIG. 11.—Arrangement of spinning places. (Redrawn from Pasteur.)

humidity is a saucer of salt; when the salt is moist, reduce the humidity. Carefully avoid disturbing the worms while spinning, and then, as during all the ages, keep the room as quiet as possible. The most scrupulous cleanliness should always be observed, both with regard to the quarters and the attendants; to keep from raising dust, wipe the floor with a damp cloth instead of sweeping it.

PREPARING COCOONS FOR THE MARKET.

The transformation of the larva into the chrysalis is, according to the temperature, completed in from seven to ten days from the time at which the first worm begins to spin. The cocoons are then said to be mature, and this is the best time to gather them. If gathered earlier, the producer will run the risk of having his cocoons rejected in the market; and if later, he will sustain a very sensible loss in their weight, as they grow lighter from the time of their maturity until the moth comes out. The best authority estimates the minimum loss as 4.1 per cent, and the maximum as 23.3 per cent. To avoid the risk of soiling them, gather the cocoons from the lowest shelf up. They may be freed from the web or floss by a very simple instrument (fig. 12) or by hand.

After the removal of the web the cocoons are sorted into three classes: (1) The perfect, (2) the double, and (3) the defective or

spoiled. They are then spread out in 4-inch layers, on clean shelves, in an airy, dry room, not exposed to sunlight, and very carefully guarded from rats, mice, and insects. The defective and discolored ones are put in a separate room.

The thread of a cocoon is continuous with that of the web, and diminishes in diameter within. Its length varies from 1,200 yards to 1,600 yards, and its value accordingly. Different races, sexes, and conditions of rearing often produce notable differences in weight of cocoons. Thus the weight may vary from 155 to 320 cocoons to the pound (340 to 700 to the kilogram).

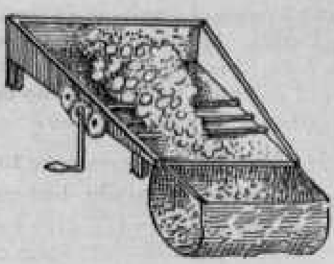

FIG. 12.—Device for removing floss from cocoons. (Redrawn from Nenci.)

Often two or more worms are inclosed in the same cocoon. Cocoons formed from such collaboration are larger than single ones, irregular in form, and cottony in texture. They can not be unreeled, and consequently are far less valuable than single ones.

The proportion of silk in a cocoon varies according to the race and the régime to which the worm has been subjected. The average normal cocoon at the time it is sold is thus composed:

	Per cent.
Water	68.2
Silk	14.3
Web and veil	.7
Chrysalis	16.8

If the cocoons are not sold as soon as gathered, the chrysalides should be killed without delay unless they are to be reserved for reproduction. Otherwise the moths may pierce the cocoons, thus rendering them unfit to be reeled.

The chrysalides are usually killed either by heat or suffocation. The means most commonly employed are (1) the heat of the sun; (2) hot dry air in a stove; (3) hot humid air in a stove; (4) steam; (5) oil of turpentine; (6) carbon bisulphid or some other gas. Probably the best of these means are steam at a temperature not above 212° F. applied without pressure, or hot damp air at a temperature of 196° F.

The killing of the chrysalides is an important operation and one requiring care and judgment. If some are left alive, the moths will issue, thus rendering the cocoons of little value. On the other hand, if the operation is continued too long, the silk may be injured. The best methods are those in which the heat is carefully controlled and excessive dryness is avoided.

The following is a very simple and easy way to destroy the chrysalides by the use of steam:

Place a cauldron of water on a stove. When boiling begins set over the cauldron a white hollow wooden cylinder, about 3 feet high and 2 feet in diameter, with

a perforated bottom and open at the top. Arrange in this cylinder round baskets three-fourths filled with cocoons; then cover tho cylinder with a perforated lid. In about thirty minutes tho operation will bo completed, after which remove the cylinder, take out tho baskets, and spread out the cocoons to dry before storing, to prevent them from spoiling.

Mr. T. A. Kelcher of this office has adopted the following plan:

The cocoons are placed in an air-tight box of about 24 cubic feet capacity; about half an ounce of bisulphid of carbon in a small dish is placed in the box and left over night. It is best to open one or two of the cocoons to find if the chrysalides are dead; if not the operation must be repeated. Care should be exercised that no fire of any kind be brought into the vicinity during this operation as the bisulphid of carbon is very inflammable.

In shipping cocoons care must be taken to pack them in baskets or cases permeable to air, but sufficiently close to keep out rats and mice, which are very destructive to cocoons.

DISEASES OF SILKWORMS.

In every successful rearing of an ounce of eggs about 40,000 worms are hatched, and 30,000 succeed in spinning cocoons. The rest either die from casual wounds or from diseases incidental to restricted action. But sometimes whole chambers are destroyed by hereditary and contagious diseases, and it is of supreme importance to cultivators to learn how these scourges may be avoided.

In this limited treatise only a bare mention can be made of the most fatal diseases and of the necessary precautions to be taken to guard against them. The general cause of disease is the domestication of the worm. By using good eggs, however, and following the methods which are actually employed by successful rearers, remunerative results are usually obtained. To obtain good eggs it is necessary to adopt new methods. These are chiefly such as involve the use of the microscope.

Among the many diseases of silkworms, the principal ones are:

Pebrine, flacherie or flaccidity, gattine or macilenza, calcino or muscardine, and grasserie.

PEBRINE.

This disease was first noticed in epidemic form in France in 1845. Since then it has appeared in Italy, Spain, Portugal, Turkey, Turkestan, the Caucasus, Kashmir, China, and Japan, threatening to destroy the silk industry.

Between 1833 and 1865 the annual crop of cocoons in France was reduced by pebrine from 57,200,000 pounds to 8,800,000 pounds. No remedy has been found for the disease, but the Pasteur microscopical selection of eggs, insuring the birth of healthy worms, is a sure preventive. The universal adoption of this method has made pebrine almost a thing of the past; and following Pasteur's line of research, means have now been discovered for avoiding every kind of silkworm disease.

Worms affected with pebrine develop slowly, irregularly, and very unequally. Black spots are the most marked outward characteristics of the disease; the internal signs are oval corpuscles only visible through the microscope.

Worms healthy born may contract pebrine during life, but this may not prevent their spinning, as the disease does not reach its climax before the chrysalid or moth stage, and in its incipiency the worm is strong enough to spin, though the moth will produce diseased eggs. Hence the necessity of repeating the microscopical examination for each generation of worms.

Pebrine is not always visible, and when latent induces other diseases. When only one crop of cocoons is made annually, it is comparatively easy to resist pebrine, as the germ of it, outside of an egg, retains its vitality not longer than seven months. The disease takes thirty days to develop; therefore, if worms from pebrinized eggs can be made to spin within twenty-five days after hatching, they may yield a fair harvest of cocoons. In any case, however, it is only safe to use pure eggs, as pebrine, even in undeveloped stages, renders the worm more liable to contract all other diseases.

FLACHERIE, OR FLACCIDITY.

This is now the most dreaded disease among European silkworms. In general, worms are struck with it after their fourth molt, when they are mature, or even while spinning (fig. 13).

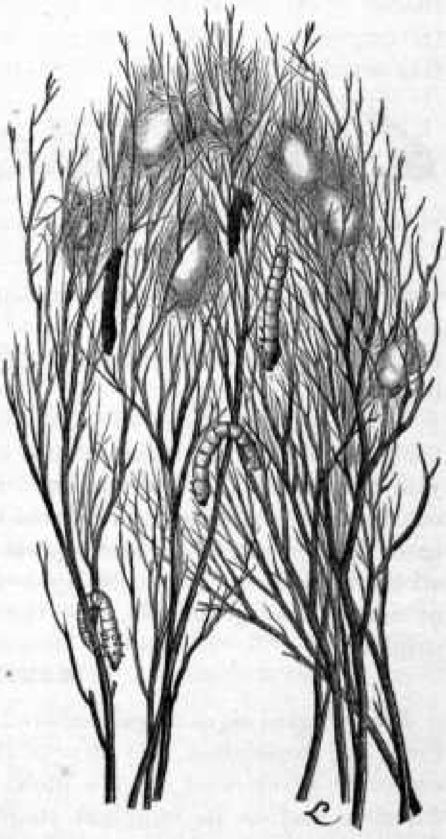

FIG. 13.—Worms affected with flacherie dying in the brush (after Pasteur).

Without any apparent cause, they begin to languish, then remain completely still, and shortly die. They blacken after death (fig. 14), and give out a disagreeable odor. Often entire chambers perish in a day. Again, the progress of the disease may be slow, the worms even spinning their cocoons, but, dying in the chrysalid state, they putrefy and soil the cocoon, thus greatly diminishing the value of the harvest. Flacherie is but another name for indigestion. Pasteur and many

other scientists assert that flacherie is due to ferments and vibrioni developing in the intestinal canal of the worm; other authorities maintain that the disease may exist independently of these. However, as these micro-organisms, in the majority of cases, play a prominent part in the development of flacherie, it is well to guard against them.

The principal causes of flacherie are: (1) Eggs being spoiled through careless preservation; (2) hereditary tendency; (3) overfeeding of worms; (4) wet, sweating, dewy, and fermented leaf; (5) leaf submerged in water or full of mud; leaf from a new plantation or from a shaded spot, coarse leaf, or change of leaf; (7) lack of ventilation; (8) excessive heat; (9) dust; (10) keeping worms too thick on trays; (11) accidental deaths of worms from injuries, these putrefying, and the ferments thus created being communicated to other worms; (12) debility.

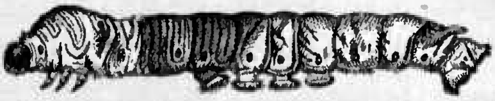

FIG. 14.—Worm which died of flacherie, putrefying after death. (Redrawn from Pasteur.)

If these causes are avoided, flacherie is not likely to invade a rearing. To prevent contagion eggs should be dipped in a solution of sulphate of copper before being incubated; and in cleaning shelves and nets, wherever a dead worm is seen, powdered sulphate of lime or copper should be applied.

Unlike the corpuscles of pebrine, the microscopic organisms, which are probably the immediate cause of flacherie, remain alive from one year to another, and the dust of a rearing room may contain them in considerable quantities and become the means of infection. Hence, in cases of flacherie, immediately after the rearing, the walls, shelves, and all the implements should be washed in a solution of chloride of lime or some other germicide, and the room should be fumigated with sulphur.

GATTINE.

The external signs of gattine are indifference to food, torpor, dysentery, and emaciation. It attacks the worm in the first ages, and is especially manifested after a molt. Sometimes it is associated with flacherie, and, in its incipient stage, is confounded with this disease. Later the worm becomes extraordinarily emaciated and sufficiently transparent to be mistaken for a mature larva. The hooks of the prolegs are lengthened out and strongly attach the worm to whatever it touches. Meanwhile torpor creeps on and soon ends its life (fig. 15).

Worms having flacherie or gattine do not always die before mounting into the brush, and if the disease has not entirely invaded the organism they may even arrive at spinning. But instead of mounting with the promptness and rapidity of healthy worms, they stop hesitatingly at the base of the brush, then begin slowly to mount, stopping

on the first little twigs and distending themselves as though asleep, sometimes with the head turned towards the base. Again, especially in case of gattine, the worm wanders restlessly here and there, seeking as it were power to eject the silky matter, but too impotent to do more than throw out a scanty thread to weave a web or veil of a cocoon, in which it generally falls and dies.

FIG. 15.—Worm emaciated by gattine after the fourth molt. (Redrawn from Nenci.)

Eggs free from disease and capable of resistance to disease are the prime requisite in guarding against flacherie and gattine. The moment some deaths are noticed, proceed as follows: (1) Change beds immediately, briskly shaking the worms; (2) place the worms on disinfected shelves; (3) burn the diseased and suspected worms that do not mount on fresh beds; (4) if possible move the whole rearing to another room previously aired and disinfected, and also aired after disinfection; (5) do not feed during the three or four hours in which the change is being made; (6) keep up a little wood smoke in the room; (7) give a few scanty meals of light leaf; and (8) diminish the temperature a little.

CALCINO, OR MUSCARDINE.

This disease, at first, has no visible appearance, but by degrees the vitality of the worm is impaired, and it eats and moves slowly. The body turns rose-colored or red, beginning with the stigmates, and then contracts and loses its elasticity, after which the worm stands still as though paralyzed, and finally dies 20 to 30 hours from the appearance of the first symptoms. After death the body dries up and is covered with a white efflorescence, causing it to look like a stick of white chalk (fig. 16); hence the name of the disease.

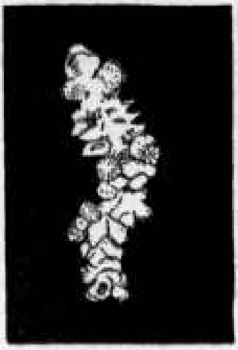

FIG. 16.—Calcinated worm. (Redrawn from Verson and Quajat.)

Calcino is caused by a mold or minute fungus. There are two varieties of this fungus: *Botrytis bassiana* and *B. tenella.* They both attack the worm in the same way The spores of the mold by chance get on the body of the worm when it is in a molting condition, and there take root, penetrating below the skin. The thread-like mycelium ramifies until it fills the entire body. Later some of the branches fructify on the surface, and the fruit bursting envelops the worm with innumerable spores resembling a white powder.

Each spore is capable of settling on a molting worm and giving it calcino, hence the necessity of taking steps to avoid contagion. Calcino is more contagious than other silkworm diseases. Darkness, stagnant air, dirt, warmth, and moisture are the five things that favor mold, and calcino is a mold.

The chief cause of the disease is neglecting to change the beds and keeping litter in and around the room. When only one or two worms have died from calcino all the shelves should at once be cleaned and divested of dead worms. The floor should be washed with a solution of sulphate of copper (1 to 200 by weight), and a pound of sulphur should be burned, or a strong wood smoke created in the room, which should then be shut up five or six hours, after which the worms should be fed. Should any worms die the next day the beds should again be changed and an ounce of sulphur burned. The quantity of sulphur fumes that would kill rats, bats, and lizards and even human beings does no harm to silkworms. No hesitation, therefore, need be felt in fumigating the rearing room with sulphur; but eggs and thread nets must not be subjected to sulphur fumes. Silkworms affected with calcino die before the moth stage; therefore, it is impossible for the disease to be hereditary. But loose spores of the mold creating the disease may get on healthy eggs. These may be washed off by a good bath of fresh water. Some recommend a bath with a solution of sulphate of copper (one-half per cent of copper). In cases of calcino the room should be disinfected immediately after the cocoons are gathered and the paper and brush used should be burned.

As calcino is never due to infected eggs no attention need be paid to the presence of spores of the Botrytis in the microscopic examination to select eggs.

GRASSERIE.

Silkworms having this disease become restless, bloated, and yellow. If punctured they exude a purulent matter full of minute polyhedral, granular crystals.

Grasserie is neither hereditary nor contagious. Unlike pebrine, flacherie, and calcino, it is not caused by microbes capable of multiplying and creating plagues. Grasserie does little harm to silkworms in Europe, but in warm countries, as in Bengal, sometimes assumes an epidemic form.

Worms first fed on mature leaf, and afterward on young leaf, are apt to take grasserie. The propagation of large trees is the best means of checking the disease. The main cause of the sporadic appearance of grasserie is mismanagement of the worms at the molting periods. Feeding should not be stopped before all the worms have begun to molt, and should not be recommenced until all the worms are well out of the molt; otherwise they are likely to have grasserie. This disease often leads to flacherie, and when it occurs in an exaggerated form indicates latent pebrine.

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